

CHAPTER 10



Knowledge-Based Decision Support: Artificial Intelligence and Expert Systems

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Knowledge-Based Decision Support: Artificial Intelligence and Expert Systems

- Managerial Decision Makers are *Knowledge Workers*
- Use Knowledge in Decision Making
- Accessibility to Knowledge Issue
- Knowledge-Based Decision Support: Applied Artificial Intelligence



AI Concepts and Definitions

- Encompasses Many Definitions
- AI Involves Studying Human **Thought Processes**
- Representing Thought Processes on Machines



Artificial Intelligence

- **Behavior** by a machine that, if performed by a human being, would be considered **intelligent**
- “...study of how to make computers do things at which, at the moment, people are better” (Rich and Knight [1991])
- Theory of how the **human mind** works (Mark Fox)



AI Objectives

- Make machines *smarter* (primary goal)
- Understand what *intelligence* is (Nobel Laureate purpose)
- Make machines more *useful* (entrepreneurial purpose)

(Winston and Prendergast [1984])



Signs of Intelligence

- ***Learn or understand* from experience**
- **Make sense out of ambiguous or contradictory messages**
- **Respond quickly and successfully to new situations**
- **Use *reasoning* to solve problems**



More Signs of Intelligence

- Deal with perplexing situations
- *Understand* and *infer* in ordinary, rational ways
- Apply *knowledge* to manipulate the environment
- *Think* and *reason*
- Recognize the relative importance of different elements in a situation



Turing Test for Intelligence

A computer can be considered to be *smart* only when a human interviewer, “conversing” with both an unseen human being and an unseen computer, can not determine which is which



Symbolic Processing

- Use *Symbols* to Represent Problem Concepts
- Apply Various Strategies and Rules to Manipulate these Concepts



AI Represents Knowledge as Sets of Symbols

A *symbol* is a string of characters that stands for some real-world concept

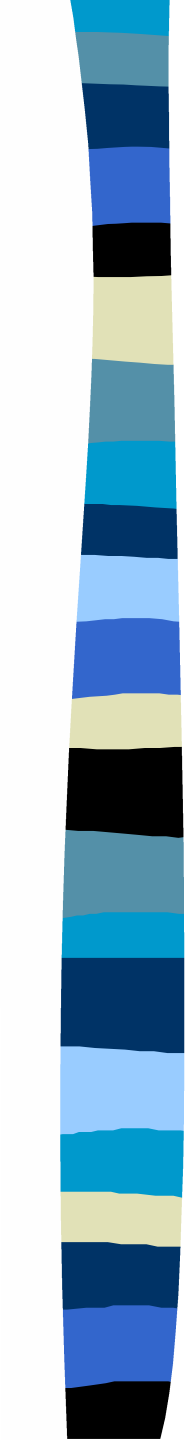
Examples

- Product
- Defendant
- 0.8
- Chocolate



Symbol Structures (Relationships)

- **(DEFECTIVE product)**
- **(LEASED-BY product defendant)**
- **(EQUAL (LIABILITY defendant) 0.8)**
- **tastes_good (chocolate).**

- 
- **AI Programs Manipulate Symbols to Solve Problems**
 - **Symbols and Symbol Structures Form Knowledge Representation**
 - **Artificial Intelligence Dealings Primarily with *Symbolic*, *Nonalgorithmic* Problem- Solving Methods**



Characteristics of Artificial Intelligence

- *Numeric versus Symbolic*
- *Algorithmic versus Nonalgorithmic*



Heuristic Methods for Processing Information

- Search
- Inferencing



Reasoning - Inferencing from **facts** and **rules** using heuristics or other search approaches

Pattern Matching - Attempt to describe objects, events, or processes in terms of their qualitative features and logical and computational relationships



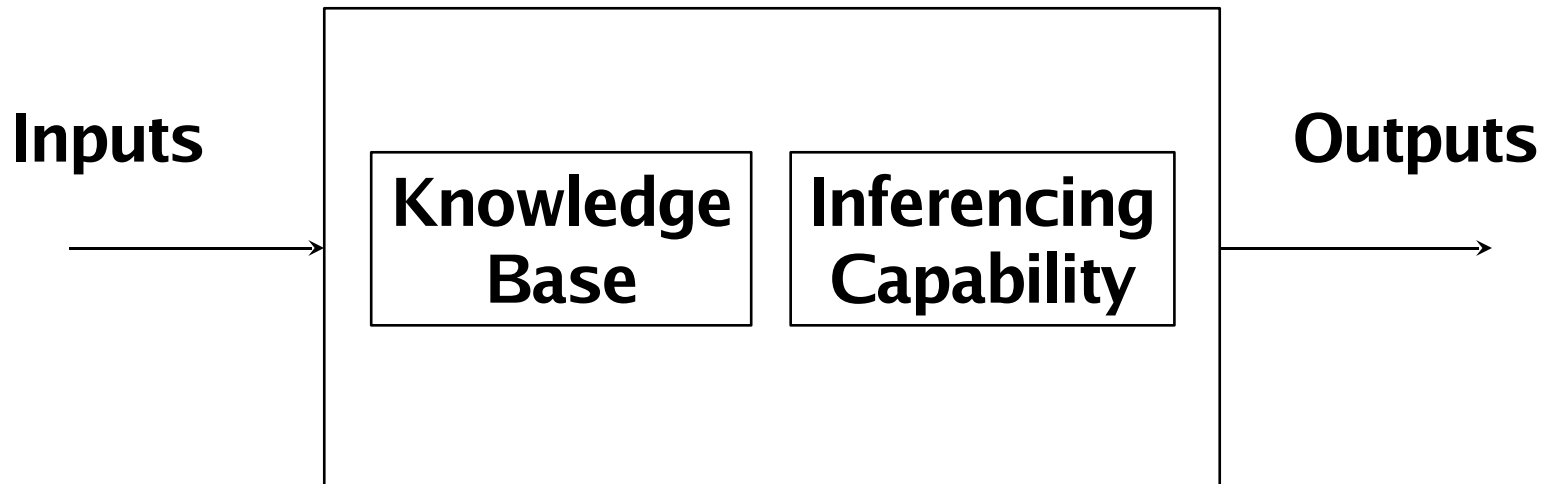
Knowledge Processing - Given facts or other representations

Knowledge Bases - Where knowledge is stored

Using the Knowledge Base in AI Programs - Inferencing

Using the Knowledge Base

Computer





Artificial Intelligence versus Natural Intelligence



AI Advantages Over Natural Intelligence

- More *permanent*
- *Ease of duplication and dissemination*
- *Less expensive*
- *Consistent and thorough*
- Can be *documented*
- Can execute certain tasks much *faster* than a human
- Can perform certain tasks *better* than many or even most people



Natural Intelligence Advantages over AI

- Natural intelligence is *creative*
- People *use sensory experience* directly
- Can use a *wide context of experience* in different situations

AI - Very Narrow Focus



Information Processing

- Computers can collect and process information efficiently
- People instinctively:
 - Recognize relationships between things
 - Sense qualities
 - Spot patterns indicating relationships
- ***BUT, AI technologies can provide significant improvement in productivity and quality!***



AI Computing

- Based on *symbolic representation* and manipulation
- A *symbol* is a letter, word, or number representing objects, processes, and their relationships
- *Objects* can be people, things, ideas, concepts, events, or statements of fact
- Creates a *symbolic knowledge base*

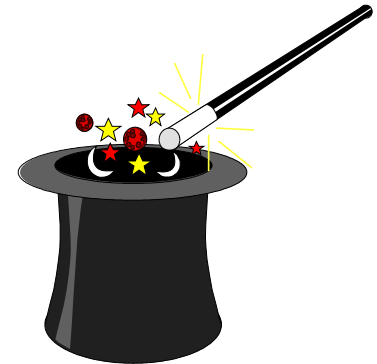


AI Computing (cont'd)

- **Manipulates symbols to generate advice**
- **AI reasons or infers with the knowledge base by search and pattern matching**
- **Hunts for answers (via algorithms)**

AI Computing (cont'd)

- ***Caution: AI is NOT magic***
- **AI is a unique approach to programming computers**





Does a Computer Really Think?

- **WHY?**
- **WHY NOT?**
- **Dreyfus and Dreyfus [1988] say NO!**
- **The Human Mind is Very Complex**
- **Kurzweil says *Soon***



AI Methods are Valuable

- **Models of how we think**
- **Methods to apply our intelligence**
- **Can make computers easier to use**
- **Can make more knowledge available**
- ***Simulate* parts of the human mind**



The AI Field

- **Many Different Sciences & Technologies**
 - Linguistics
 - Psychology
 - Philosophy
 - Computer Science
 - Electrical Engineering
 - Hardware and Software



(More)

- **Mechanics**
- **Hydraulics**
- **Physics**
- **Optics**
- **Others**

■ **Commercial, Government and Military Organizations**



Plus

- **Management and Organization Theory**
- **Chemistry**
- **Physics**
- **Statistics**
- **Mathematics**
- **Management Science**
- **Management Information Systems**



Artificial Intelligence

- **A Science and a Technology**
- **Growing Commercial Technologies**



Major AI Areas

- **Expert Systems**
- **Natural Language Processing**
- **Speech Understanding**
- **Robotics and Sensory Systems**
- **Computer Vision and Scene Recognition**
- **Intelligent Computer-Aided Instruction**
- **Neural Computing**



Additional AI Areas

- **News Summarization**
- **Language Translation**
- **Fuzzy Logic**
- **Genetic Algorithms**
- **Intelligent Software Agents**



AI Transparent in Commercial Products

- **Anti-lock Braking Systems**
- **Video CAMcorders**
- **Appliances**
 - Washers
 - Toasters
 - Stoves
- **Data Mining Software**
- **Help Desk Software**
- **Subway Control**



Expert Systems

- **Attempt to Imitate Expert Reasoning Processes and Knowledge in Solving Specific Problems**
- ***Most Popular Applied AI Technology***
 - Enhance Productivity
 - Augment Work Forces
- **Narrow Problem-Solving Areas or Tasks**



Expert Systems

- **Provide Direct Application of Expertise**
- **Expert Systems Do Not Replace Experts, But They**
 - **Make their Knowledge and Experience More Widely Available**
 - **Permit Nonexperts to Work Better**



Expert Systems

- Expertise
- Transferring Experts
- Inferencing
- Rules
- Explanation Capability



Expertise

- **The extensive, task-specific knowledge acquired from training, reading and experience**
 - Theories about the problem area
 - Hard-and-fast rules and procedures
 - Rules (heuristics)
 - Global strategies
 - Meta-knowledge (knowledge about knowledge)
 - Facts
- **Enables experts to be better and faster than nonexperts**



Some Facts about Expertise

- Expertise is usually associated with a high degree of intelligence, but not always with the smartest person
- Expertise is usually associated with a vast quantity of knowledge
- Experts learn from past successes and mistakes
- Expert knowledge is well-stored, organized and retrievable quickly from an expert
- Experts have excellent recall



Experts

- **Degrees or levels of expertise**
- **Nonexperts outnumber experts often by 100 to 1**



Human Expert Behaviors

- Recognize and formulate the problem
- Solve problems quickly and properly
- Explain the solution
- Learn from experience
- Restructure knowledge
- Break rules
- Determine relevance
- Degrade gracefully

Transferring Expertise

- **Objective of an expert system**
 - To transfer expertise from an expert to a computer system and
 - Then on to other humans (nonexperts)
- **Activities**
 - Knowledge acquisition
 - Knowledge representation
 - Knowledge inferencing
 - Knowledge transfer to the user
- **Knowledge is stored in a *knowledge base***





Two Knowledge Types

- **Facts**
- **Procedures (usually rules)**

Regarding the Problem Domain



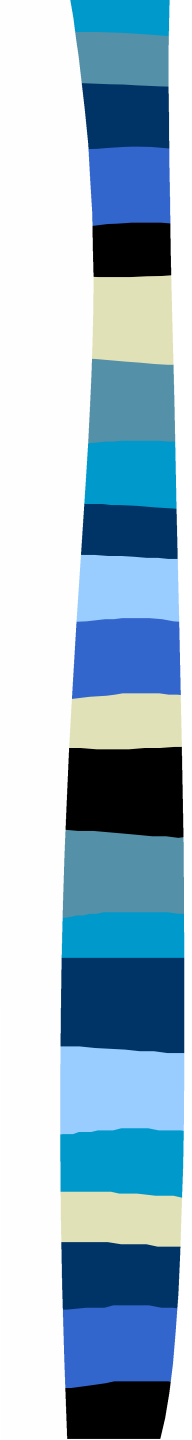
Inferencing

- **Reasoning** (Thinking)
- The computer is programmed so that it can make inferences
- Performed by the *Inference Engine*



Rules

- **IF-THEN-ELSE**
- **Explanation Capability**
 - **By the justifier, or explanation subsystem**
- **ES versus Conventional Systems**



Structure of Expert Systems

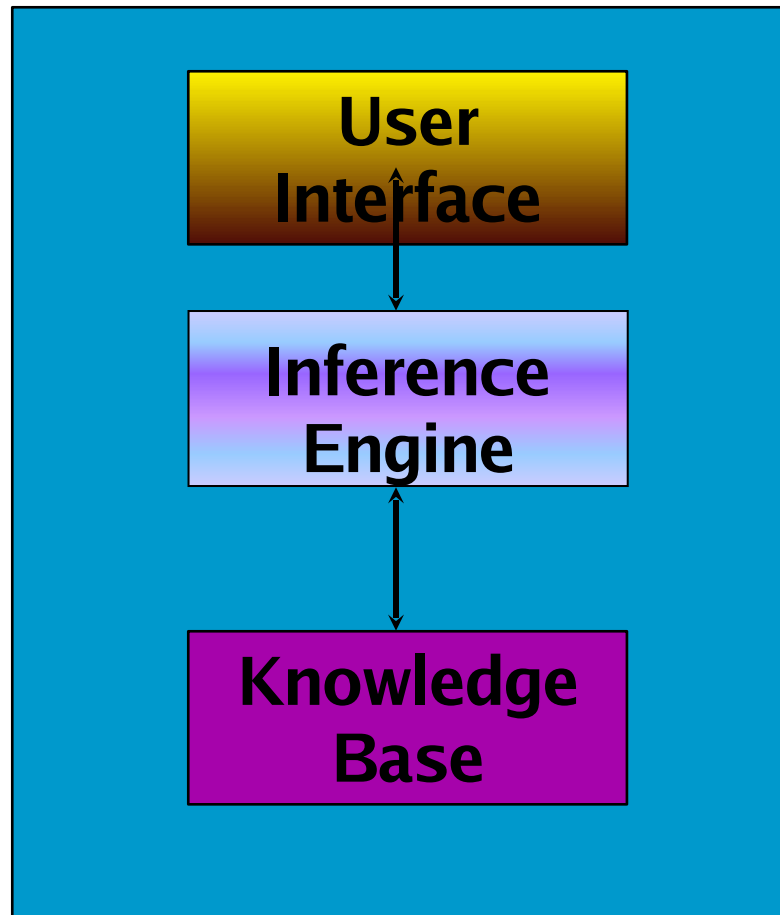
- **Development Environment**
- **Consultation (Runtime) Environment**



Three Major ES Components

- Knowledge Base
- Inference Engine
- User Interface

Three Major ES Components





All ES Components

- Knowledge Acquisition Subsystem
- **Knowledge Base**
- **Inference Engine**
- **User Interface**
- Blackboard (Workplace)
- Explanation Subsystem (Justifier)
- Knowledge Refining System
- User

- Most ES *do not have* a Knowledge Refinement Component

(See Figure 10.3)



Knowledge Acquisition Subsystem

- **Knowledge acquisition is the accumulation, transfer and transformation of problem-solving expertise from experts and/or documented knowledge sources to a computer program for constructing or expanding the knowledge base**
- **Requires a knowledge engineer**



Knowledge Base

- The knowledge base contains the knowledge necessary for understanding, formulating, and solving problems
- Two Basic Knowledge Base Elements
 - Facts
 - Special heuristics, or rules that direct the use of knowledge
 - Knowledge is the primary raw material of ES
 - **Incorporated knowledge representation**



Inference Engine

- The *brain* of the ES
- The control structure (rule interpreter)
- Provides methodology for reasoning



Inference Engine Major Elements

- Interpreter
- Scheduler
- Consistency Enforcer



User Interface

- **Language processor** for friendly, problem-oriented communication
- NLP, or menus and graphics



Blackboard (Workplace)

- **Area of working memory to**
 - **Describe the current problem**
 - **Record Intermediate results**
- **Records Intermediate Hypotheses and Decisions**
 - 1. Plan**
 - 2. Agenda**
 - 3. Solution**



Explanation Subsystem (Justifier)

- **Traces responsibility and explains the ES behavior by interactively answering questions**
 - Why?
 - How?
 - What?
 - (Where? When? Who?)
- **Knowledge Refining System**
 - **Learning for improving performance**



The Human Element in Expert Systems

- Expert
- Knowledge Engineer
- User
- Others



The Expert

- Has the special knowledge, judgment, experience and methods to **give advice** and **solve problems**
- Provides knowledge about task performance



The Knowledge Engineer

- Helps the expert(s) structure the problem area by interpreting and integrating human answers to questions, drawing analogies, posing counterexamples, and bringing to light conceptual difficulties
- Usually also the **System Builder**

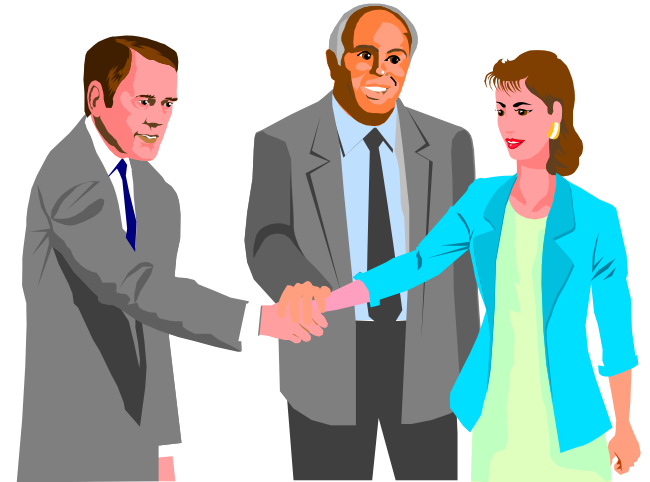


The User

- **Possible Classes of Users**
 - A non-expert client seeking direct advice (ES acts as a *Consultant* or *Advisor*)
 - A student who wants to learn (*Instructor*)
 - An ES builder improving or increasing the knowledge base (*Partner*)
 - An expert (*Colleague* or *Assistant*)
- **The Expert and the Knowledge Engineer Should Anticipate Users' Needs and Limitations When Designing ES**

Other Participants

- **System Builder**
- **Systems Analyst**
- **Tool Builder**
- **Vendors**
- **Support Staff**
- **Network Expert**





How Expert Systems Work

Major Activities of ES Construction and Use

- Development
- Consultation
- Improvement



ES Development

- Knowledge base development
- Knowledge separated into
 - *Declarative* (factual) knowledge and
 - *Procedural* knowledge
- Development (or Acquisition) of an inference engine, blackboard, explanation facility, or any other software
- Determine knowledge representations



Participants

- **Domain Expert**
- **Knowledge Engineer and**
- **(Possibly) Information System Analysts and Programmers**



ES Shell

- Includes All Generic ES Components
- But *No Knowledge*
 - EMYCIN from MYCIN
 - (E=Empty)



Expert Systems Shells Software Development Packages

- Exsys
- InstantTea
- K-Vision
- KnowledgePro



Consultation


- Deploy ES to Users (Typically Novices)
- ES Must be *Very Easy* to Use
- ES Improvement
 - By **Rapid Prototyping**



An Expert System at Work

Exsys Demo - Section 10.10

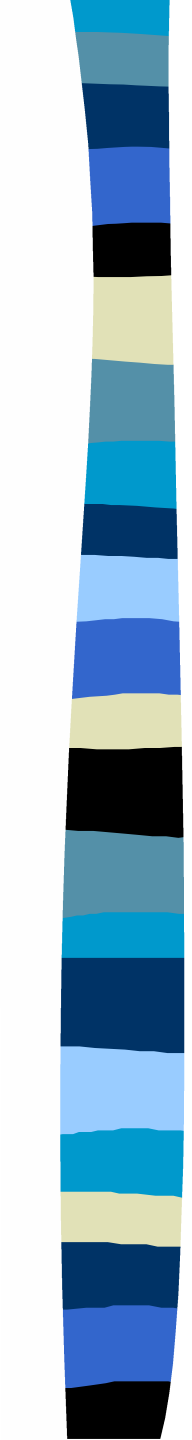
Problem Areas Addressed by Expert Systems

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- Interpretation systems
 - Prediction systems
 - Diagnostic systems
 - Design systems
 - Planning systems
 - Monitoring systems
 - Debugging systems
 - Repair systems
 - Instruction systems
 - Control systems



Expert Systems Benefits

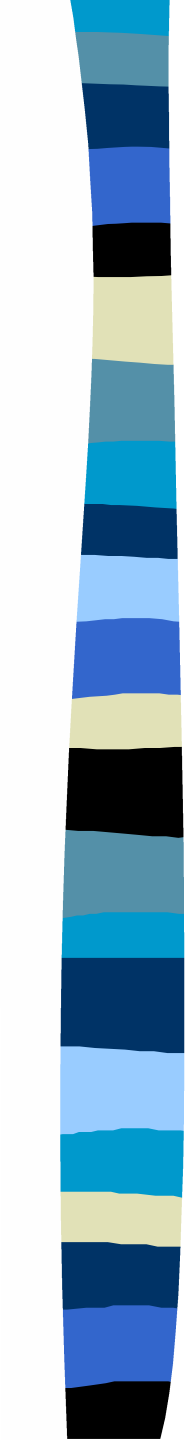
- Increased Output and Productivity
- Decreased Decision Making Time
- Increased Process(es) and Product Quality
- Reduced Downtime
- Capture Scarce Expertise
- Flexibility
- Easier Equipment Operation
- Elimination of Expensive Equipment

- 
- **Operation in Hazardous Environments**
 - **Accessibility to Knowledge and Help Desks**
 - **Integration of Several Experts' Opinions**
 - **Can Work with Incomplete or Uncertain Information**
 - **Provide Training**
 - **Enhancement of Problem Solving and Decision Making**
 - **Improved Decision Making Processes**
 - **Improved Decision Quality**
 - **Ability to Solve Complex Problems**
 - **Knowledge Transfer to Remote Locations**
 - **Enhancement of Other MIS**



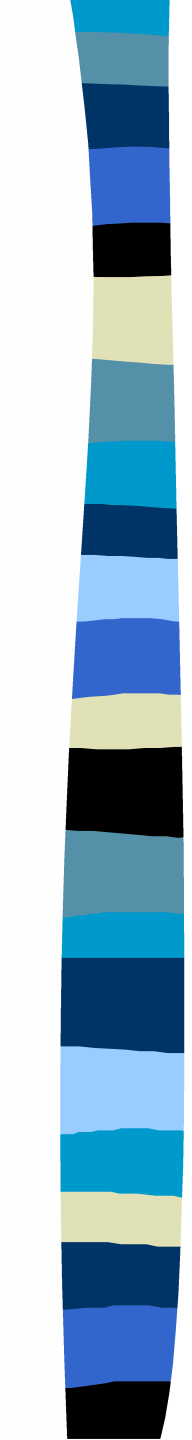
Lead to

- **Improved decision making**
- **Improved products and customer service**
- **Sustainable strategic advantage**
- **May enhance organization's image**



Problems and Limitations of Expert Systems

- Knowledge is not always readily available
- Expertise can be hard to extract from humans
- Each expert's approach may be different, yet correct
- Hard, even for a highly skilled expert, to work under time pressure
- Expert system users have natural cognitive limits
- ES work well only in a *narrow domain* of knowledge

- 
- **Most experts have no independent means to validate their conclusions**
 - **Experts' vocabulary often limited and highly technical**
 - **Knowledge engineers are rare and expensive**
 - **Lack of trust by end-users**
 - **Knowledge transfer subject to a host of perceptual and judgmental biases**
 - **ES may not be able to arrive at valid conclusions**
 - **ES sometimes produce incorrect recommendations**



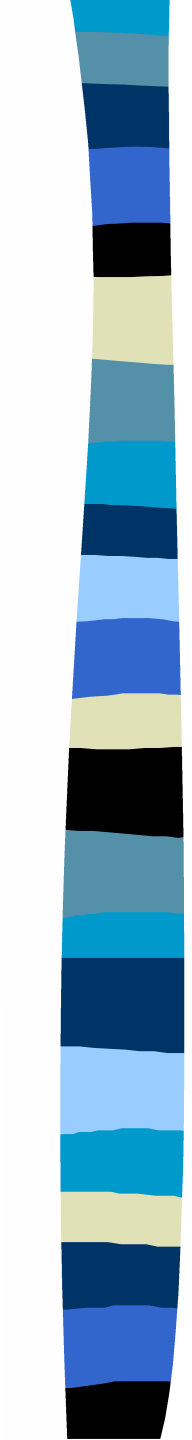
Expert System Success Factors

- **Most Critical Factors**

- **Champion in Management**
- **User Involvement and Training**

- **Plus**

- **The level of knowledge must be sufficiently high**
- **There must be (at least) one cooperative expert**
- **The problem to be solved must be qualitative (fuzzy), not quantitative**
- **The problem must be sufficiently narrow in scope**
- **The ES shell must be high quality, and naturally store and manipulate the knowledge**

- 
- **A friendly user interface**
 - **The problem must be important and difficult enough**
 - **Need knowledgeable and high quality system developers with good people skills**
 - **The impact of ES as a source of end-users' job improvement must be favorable. End user attitudes and expectations must be considered**
 - **Management support must be cultivated.**

- **Need end-user training programs**
- **Organizational environment should favor new technology adoption (freedom to fail)**



For Success

- 1. Business applications justified by strategic impact (competitive advantage)**
- 2. Well-defined and structured applications**



Longevity of Commercial Expert Systems

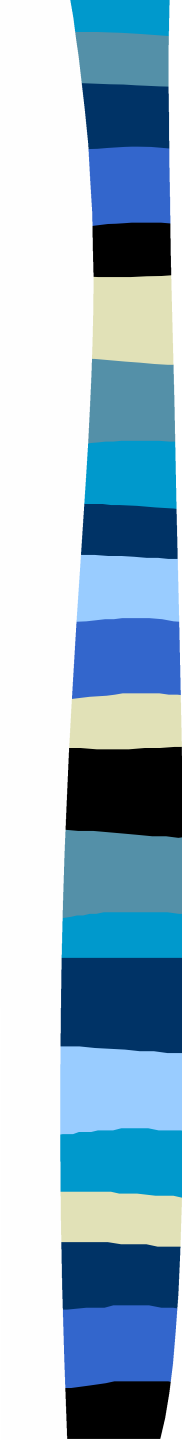
- Only about one-third survived five years
- Generally ES Failed Due to Managerial Issues
 - Lack of system acceptance by users
 - Inability to retain developers
 - Problems in transitioning from development to maintenance
 - Shifts in organizational priorities
- Proper management of ES development and deployment could resolve most

(Gill [1995])



Expert Systems Types

- **Expert Systems Versus Knowledge-based Systems**
- **Rule-based Expert Systems**
- **Frame-based Systems**
- **Hybrid Systems**
- **Model-based Systems**
- **Ready-made (Off-the-Shelf) Systems**
- **Real-time Expert Systems**



Expert Systems and the Web/Internet/Intranets

- 1. Use of ES on the Net**
- 2. Support ES (and other AI methods)**



Using ES on the Web

- **Provide knowledge and advice**
- **Help desks**
- **Knowledge acquisition**
- **Spread of multimedia-based expert systems (Intelimedia systems)**

- **Support ES and other AI technologies provided to the Internet/Intranet**